nicolle 1-10-01



Ins a1> ~~DESCRIPTION~~

Ins a2>

Ins a3> The present invention relates to a capacity controller of a compressor with variable capacity used for a refrigerating cycle of an automobile air conditioner or the like, in accordance with the preamble part of claim 1, claim 4, claim 5, and to a method according to the preamble part of claim 8 and claim 9.

Ins a4>

As the compressor in a refrigerating cycle of an automobile air conditioner directly is driven by the engine of the automobile the speed of the compressor cannot be controlled individually. In order to obtain proper refrigerating abilities without being limited by the engine speed compressors with variable capacity are used allowing to vary their capacity (the amount of discharged refrigerant) upon cooling or heating demand independent from the speed of the engine. The compressor may be a rotary compressor, a scroll compressor or a swash plate compressor. The capacity is controlled by controlling the inhalation pressure with the help of an energisation force brought onto a diaphragm by an electromagnetic solenoid. Due to said diaphragm also the pressure of the ambient air is applied. A capacity variation mechanism is controlled by the inhalation pressure. A capacity control mechanism having said diaphragm is complicated to operate, because the structure of the control mechanism is complicated and large in size, and because the available control range of the inhalation pressure is restricted. As a consequence, it is difficult, to control the compressor properly within a wide range of conditions.

Ins a5>

It is an object of the present invention to provide a capacity control apparatus of a compressor with variable capacity which can be of compact size and structurally simple and which allows to obtain wide control range, and to propose a method for controlling the capacity of the compressor properly within a broader control range compared with the useable control range of only the inhalation pressure.

Said task is achieved with the features contained in claim 1, with the feature combination of claim 4 or claim 5, and by the method as disclosed in claims 8 or 9.

According to the invention a wide control range is obtained with a compact and small sized control apparatus having a simple configuration. This is achieved by controlling the capacity of the compressor with the help of a differential pressure added to the

inhalation pressure on an arbitrary level with the help of a controlling piston valve body, loaded inter alia by a solenoid. Additionally, the inhalation pressure is applied to the piston valve body so that a value of the differential pressure can be maintained and set arbitrary for the transmission into the capacity variation mechanism to correspondingly adjust the capacity of the compressor. Basically, the differential pressure used in connection with the inhalation pressure is derived from a discharge pressure of the compressor allowing to broaden the pressure variation range for the capacity variation mechanism. The inhalation pressure remains the leading control parameter. However, not only the inhalation pressure and/or its pressure variations control the capacity variation mechanism, but in addition an assistant differential pressure is taken from the discharge pressure of the compressor and is added. The magnitude of the differential pressure may be adjusted and varied by a solenoid, e.g. a proportional solenoid

Ins. a6

Embodiments of the invention will be described with the help of the drawings. In the drawings is:

Fig. 1 sectional views of a capacity controller, a capacity variation mechanism and a rotary compressor integrated into a refrigerating cycle of an automobile air conditioning system,

Fig. 2 a partial cross-section of the compressor shown in Fig. 1,

Fig. 3 a partial cross-section of a detail of the compressor of Fig. 1,

Fig. 4 a schematic view of the capacity variation mechanism of Fig. 1,

Fig. 5 a view similar to Fig. 1, representing the condition of an adjustment of maximum capacity of the compressor,

Fig. 6 a view similar to Fig. 1, representing a condition of minimum capacity of the compressor,

Fig. 7 a diagram representing the control behaviour of the capacity control apparatus as used in Fig. 1, showing the value of a

differential pressure over the capacity duty of the compressor, and

Fig. 8 a view similar to Fig. 1 containing a second embodiment of a capacity control apparatus.

Ins. a7

Figs 1 to 8 show a rotary compressor 10 with variable capacity in conjunction with a capacity controller 20 and a capacity variation mechanism 30, together employed in a refrigerating cycle of an automobile air conditioner or the like. The compressor 10 has (Fig. 2) a circular housing 11 receiving a somewhat smaller circular rotor 12 disposed on an eccentric axis 13. Said rotor 12 is driven e.g. by the engine of the automobile (not shown). In the outer periphery of rotor 12 radially displaceable seal pieces 14 are biased outwardly by spring means such that they contact the inner surface of housing 11. At the closest position between the inner surface of housing 11 and periphery of rotor 12 a discharge port 19 is provided discharging compressed high pressure refrigerant into a discharge pressure duct 2. An inhalation duct 1 for low-pressure refrigerant supplied from an evaporator (not shown) communicates with an inhalation port 15a of an inhalation port control board 15. Port 15a allows to supply the low-pressure refrigerant into a compression chamber 18 of compressor 10. Board 15 has axial and oversized bore 16 for eccentric axis 13.

The capacity of the compressor 10 can be varied by increasing or decreasing the volume, i.e. the angular extension, of compression chamber 18, e.g. by rotating the inhalation control board 15 in order to displace the inhalation port 15a in rotary direction. Control board 15 has a protruding driving pin 17 which can be adjusted about the axis of board 15 by capacity variation mechanism 30.

Sub C

Mechanism 30 in Fig. 4 controls the position of the driving pin 17 in order to control the rotary orientation of the inhalation port 15a of control board. In a cylinder 31 of mechanism 30 a piston 32 is moveable in axial direction. Driving pin 17 engages into a circumferential groove 32a of piston 32. An axial movement of piston 32 automatically displaces control board 15 about its axis. Piston 32 is loaded by a spring 32 in a direction adjusting the capacity of the compressor towards a minimum. Spring 32 is received within one part of cylinder 31. Said part of cylinder 31 is also connected to inhalation duct 1 such that the pressure inside said part of the cylinder 31 corresponds

an inhalation pressure Ps of the compressor. The opposite part of cylinder 31 (at the other side of piston 32) is connected to a differential pressure port 28c of said capacity controller 20 which operates as a differential pressure controller. The pressure within the other part of cylinder 31 is a control pressure Pc the value of which is controlled by said controller 20. The higher said control pressure Pc is, the further piston 32 is displaced counter to spring 32 and the more control board 15 is rotated towards its position for maximum capacity of the compressor. The lower said control pressure Pc is, the more control board 15 rotated by spring 32 and inhalation pressure Ps towards its position of minimum capacity of the compressor 10.

Capacity controller 20, e.g. of Fig. 1, is a fixed differential pressure valve and includes a solenoid (coil 21, fixed iron core 22 and moveable iron core 23) for controlling said differential pressure also by the pressures at both ends of a piston valve body 25. The driving source of said solenoid is electromagnetic coil 21 to which electric current can be supplied upon demand (proportional solenoid, the actuation force of which directly is proportional to the value of current supplied to coil 21).

In addition springs 26, 27 are provided which act in opposite directions onto said piston valve body 25. The setting of both springs 26, 27 determines in the embodiment of Fig. 1 a basic maximum value of the differential pressure (Pc - Ps). Said value, however, can arbitrarily be decreased by feeding current into coil 21. Moveable iron core 23 is attracted the more by fixed iron 22, the stronger the current is. Moveable iron core 23 causes a thrust F which is transmitted to said piston valve body 25 via a rod 24 extending along the axis of fixed iron core 20. Thrust F is acting in opening direction of said differential pressure valve of said controller 20 in Fig. 1..

Said inhalation duct 1 is connected to an inhalation pressure port 28s provided in a side of a housing of controller 20 and behind the back or rear effective pressure area of piston valve body 25 which can be loaded in the same direction by the thrust F of moveable iron core 23.

Piston valve body 25 co-operates by a front end valve closure jaw part 25a with a valve seat 42 provided between a space 41 housing piston valve body 25 and axially disposed

differential pressure port 28c. Differential pressure port 28c of controller 20 is connected to said other part of cylinder 31 on the side of piston 32 opposite to spring 33.

As a consequence, said control pressure Pc when controlled corresponds to the inhalation pressure Ps but is higher by an increment of pressure due to the thrust F caused by moveable iron core 23 (and the setting of springs 26, 27).

Sub C3

Discharge pressure duct 2 is connected to a discharge pressure port 28d of controller 20. Discharge pressure port 20d (discharge pressure Pd) opens in the vicinity of valve seat 42 at the circumferential side of piston valve body 25, so that discharge pressure Pd does not affect the piston valve body 25 in axial direction, i.e., piston valve body 25 is pressure balanced for discharge pressure Pd.

Said valve closure jaw part 25a formed at the front end of piston valve body 25 serves to open and close said valve seat 42 between discharge pressure port 28d and differential pressure port 28c. As soon as said valve jaw part 25a is lifted from valve seat 42 during a movement of piston valve body 25 with thrust F pressure Pd from discharge pressure duct 2 is transmitted via the open valve seat 42 into differential pressure port 28c, according to the initial control condition of the controller.

Whenever the value of the pressure at the differential pressure port 28c becomes lower than the fixed value of control pressure Pc, piston valve body 25 is moved towards its opening state such that a communication is established between the discharge pressure port 28d and differential pressure port 28c. As soon as then the value of the pressure at the differential pressure port 28c reaches the fixed value of the control pressure Pc, piston valve body 25 returns into its closing state and again separates said differential pressure port 28c from said discharge pressure port 28d.

Furthermore, e.g. outside of controller 20, differential pressure port 28c and inhalation pressure port 28s are directly interconnected via a leak passage 40 having a small cross-sectional area, e.g. provided in a connection between inhalation duct 1 and a duct connecting differential pressure port 28c with mechanism 30. As soon as valve closure jaw part 25a closes valve seat 42 the value of the pressure at the differential pressure port 28c is allowed to little by little relieve via leak passage 40 into inhalation duct 1. As

a result, piston valve body 25 always axially and slightly moves and control pressure Pc is controlled to the fixed value, e.g. corresponding to the value of the electric current supplied to electromagnetic coil 21.

As shown in Fig. 5 the larger the value of the electric current in electromagnetic coil 21 is, the larger the pressure differential of (Pc - Ps) becomes, and the angular position of the inhalation port 15a is displaced in a direction towards (max) by capacity variation mechanism 30. As a result the capacity of the inhalation compression chamber 18 and consequently the discharge pressure Pd increase.

The smaller the value of the electric current in electromagnetic coil 21 is, the smaller is the differential pressure of (Pc - Ps), as shown in Fig. 6 and the angular position of inhalation port 15a is adjusted in the direction towards (min) by capacity variation mechanism 30. As a result, the capacity of said inhalation compression chamber 18 and the discharge pressure Pb both decrease.

As can be seen in Fig. 7 the capacity of compression chamber 18 of compressor 10 is varied corresponding to the differential pressure Pc - Ps by controlling the value of the electric current in electromagnetic coil 21.

The value of the electric current in electromagnetic coil 21 is controlled by inputting detected signals from an engine sensor, temperature sensors inside and outside of an automobile compartment, an evaporator sensor and a plurality of other sensors detecting specific kinds of conditions. Said signals are input into a control part 3 containing a CPU and the like. Said CPU processes the input signals and provides an output signal based on the respective operation results. The control signal is then output from control part 3 to electromagnetic coil 21, e.g. via a not shown driving circuit.

In a second embodiment of controller 20 shown in Fig. 8 piston valve body 25 is co-operating with valve seat 42' such that said valve seat 42' is closed by the front end closure part 25a' in the direction of thrust F generated by solenoid 21, 22, 23. In this embodiment discharge pressure port 28d is omitted. At the very same location instead inhalation pressure port 28s is provided. Discharge pressure duct 2 directly is connected via leak passage 40 to the duct connecting differential pressure port 28c to

the left part of cylinder 31 of mechanism 30. Inhalation pressure port 28s of the embodiment of Fig. 1 is omitted. Inhalation pressure Ps can act on piston valve body 25 in the same direction as thrust F, namely towards the closing state. The pressure in differential pressure port 28c is acting in opening direction.

Springs 26, 27 determine a basic value of differential pressure Pc - Ps. Said value can be increased arbitrarily by increasing the value of the current supplied to electromagnetic coil 21.

As soon as due to pressure passing leak passage 40 the pressure at differential pressure port 28c rises beyond the fixed value of the control pressure Pc, piston valve body 25 is lifted from its valve seat 42'. A flow communication is established between differential pressure port 28c and inhalation pressure port 28s. Control pressure Pc drops to the fixed value . As soon as the pressure at the differential pressure port 28c has reached the fixed value of the control pressure Pc, piston valve body 25 returns again into its closed state. Again high pressure refrigerant passes through leak passage 40 to differential pressure port 28c in order to maintain the fixed value of the differential pressure Pc - Ps as adjusted by the value of the current for the coil 21.

In both embodiments high pressure refrigerant from the discharge pressure duct 2 is used to build up the fixed pressure value for the control pressure Pc, however, influenced by the initial value of the inhalation pressure Ps.

The invention instead may be applied to control the capacity of a scroll compressor or the like instead of a rotary compressor 10 as shown.